Compact X-ray and Bremsstrahlung Collimator for LCLS-II

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Introduction

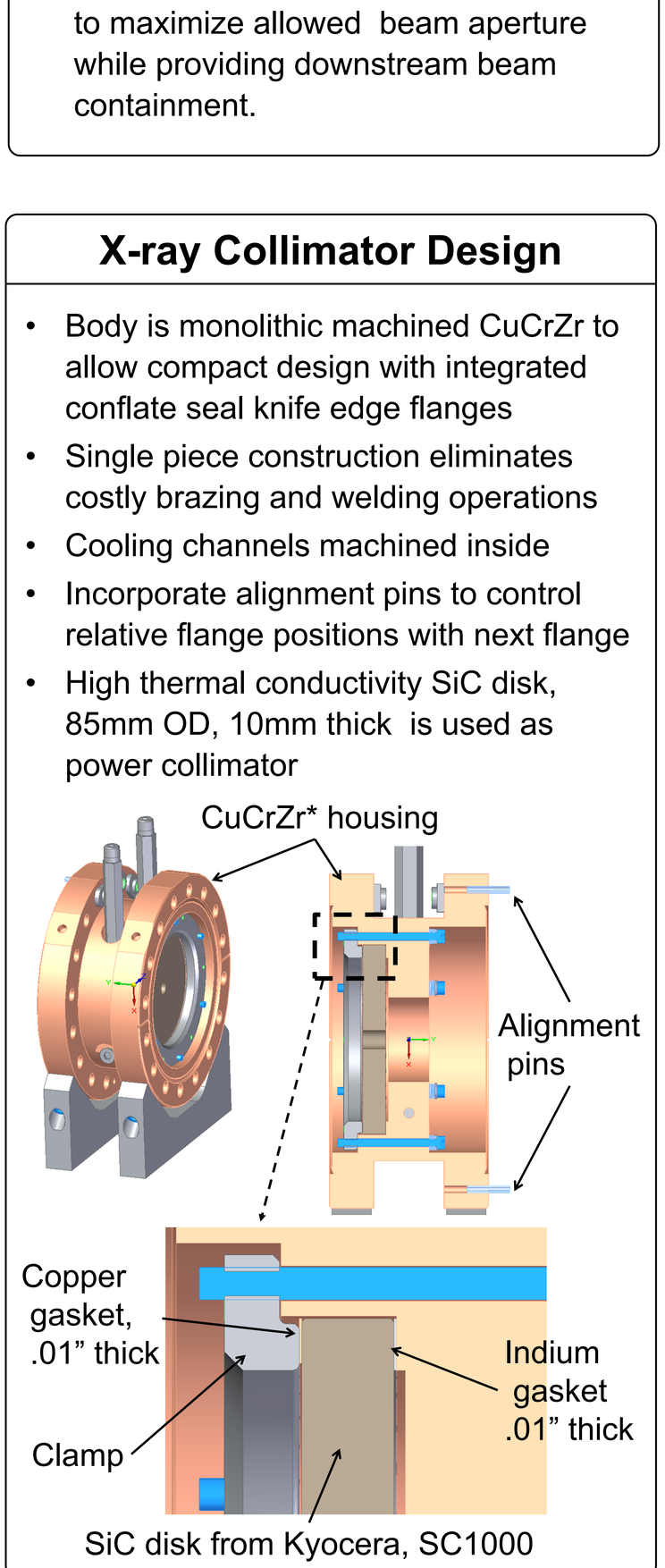
This presentation discusses a package consisting of photon collimator that intercepts and collimates the x-ray beam, Burn Through Monitor (BTM) that monitors for beam excursions from the design path, and Bremsstrahlung collimator which collimates high energy photons associated with electron beam interaction with residual gas and physical apertures.

Requirements for design package:

- Design a compact and modular x-ray power and Bremsstrahlung collimators
- X-ray collimator and absorber to handle allowed power of 100W
- Come up with fixtures and locating features to minimize the relative alignment error on assembly and hence to maximize allowed beam aperture while providing downstream beam containment.

X-ray Collimator Design

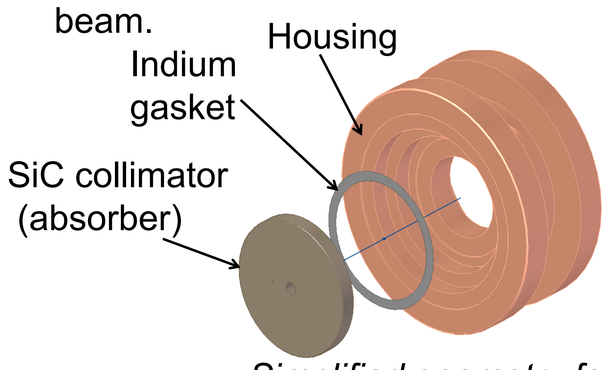
- Body is monolithic machined CuCrZr to allow compact design with integrated conflate seal knife edge flanges
- Single piece construction eliminates costly brazing and welding operations
- Cooling channels machined inside
- Incorporate alignment pins to control relative flange positions with next flange
- High thermal conductivity SiC disk, 85mm OD, 10mm thick is used as power collimator



* *Ref: Li M. and Zinkle S. J. (2012) Physical and Mechanical Properties of Copper and Copper alloys, Comprehensive Nuclear Materials, Vol. 4, pp 667-690*

Finite Element Analysis of SiC

- FEA to ensure the components that intercept the beam shall remain in safe temperature and stress regime under the maximum power of 100W and 50W/mm^2
- Two cases were analyzed: properly steered and significantly mis-steered beam.



Simplified geometry for FEA

- Thermal Conductance is applied on the interface between the SiC disk and Indium gasket.

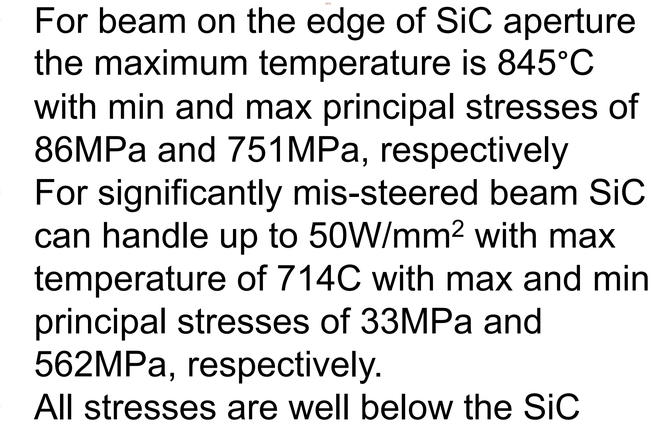
RESULTS

- For beam on the edge of SiC aperture the maximum temperature is 845°C with min and max principal stresses of 86MPa and 751MPa, respectively
- For significantly mis-steered beam SiC can handle up to 50W/mm^2 with max temperature of 714C with max and min principal stresses of 33MPa and 562MPa, respectively.
- All stresses are well below the SiC tensile and compressible strength .

Burn Through Monitor Design

Gas-filled, thin wall vessel which, if illuminated by the beam, will burn through and release the contained gas and trip pressure switches that initiate beam shutdown.

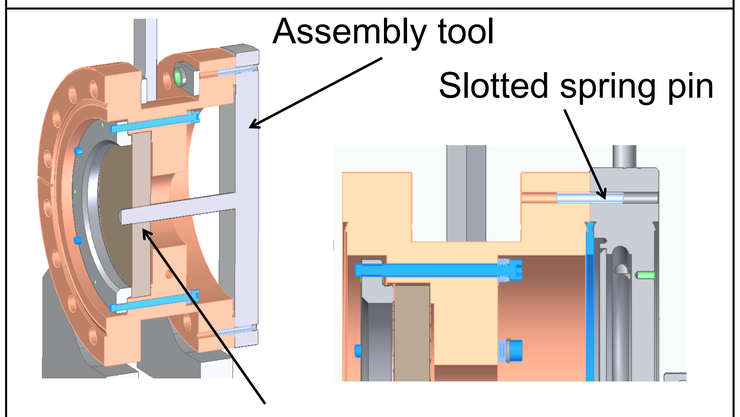
- Simple and compact design using machined double sided flanges with welded lid



Bremsstrahlung collimator

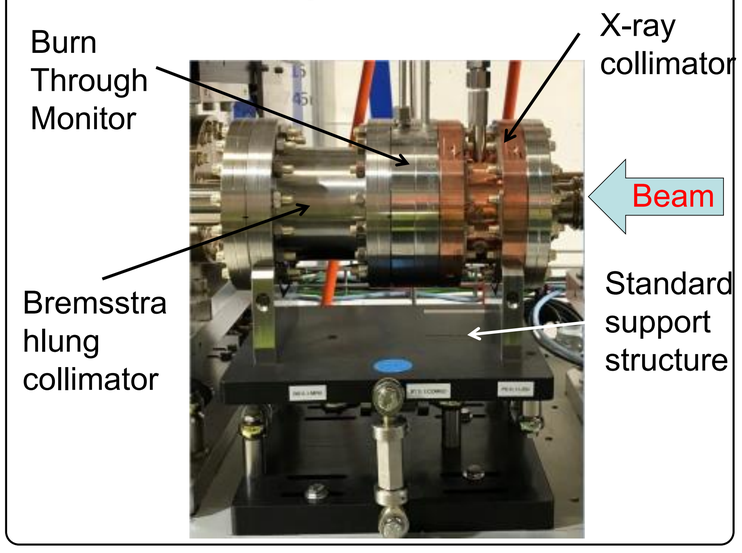
- Consists of a vacuum nipple surrounded by tungsten alloy
- Longitudinal length of tungsten alloy that intercepts beam is ≥80mm
- Shadowed by x-ray collimator and BTM

Assembly and Alignment



Diameter is sized for different Collimator apertures: 8mm, 14mm, 22mm, etc.

- Alignment pins to establish common reference and control flange position
- Assembly tool to transfer relative alignment of SiC aperture to BTM and Bremsstrahlung collimators



Conclusions

The design package is a compact, modular x-ray power and Bremsstrahlung collimator for beam containment. The FEA analysis of properly steered and significantly miss-steered beam confirmed the x-ray collimator (SiC) can handle up to 100W and 50W/mm^2 .

The assembly tools and alignment pins ensure high relative alignment tolerance. Allowed beam is maximized and good downstream beam containment is provided.

Many packages with different sizes SiC disks, BTMs, and Bremsstrahlung collimators were installed in early 2019 and are operating successfully under the designed conditions.

Acknowledgments

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